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Geotechnical Engineers & Materials Testing

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Job No. 1140202901
Trench Safety Report
March 2, 2015

Ms. Hillary Passovoy, P.E.
Bury-Hou, Inc.
7660 Woodway Drive, Suite 400
Houston, Texas 77063

Reference: Trench Safety Design Considerations
Neighborhood Street Reconstruction
(NSR) Project 456
WBS No. N-000388-0001-3
Houston, Texas

Dear Ms. Passovoy:

We are pleased to present our geotechnical information for trench safety for the referenced project.

For trench excavation, it is essential to maintain the stability of the sides and base and not to disturb the soil below the excavation grade. This is necessary to prevent any damage to adjacent facilities as a result of either vertical or lateral movements of the soil. In addition, a satisfactory excavation procedure must include an adequate construction dewatering system to lower and maintain the water level at least 3 feet below the lowest excavation grade or a minimum of 5 feet below prevailing level of backfill during backfilling. This will minimize the potential for softening or "boiling" of the base support soil.

Trench Excavation

Based on the information provided by Bury-Hou, Inc., it is understood that the water line, sanitary sewer and sanitary sewer force main will be installed by open cut method of construction. The following subsections provide information for the design and construction of the water line, sanitary sewer and sanitary sewer force main open cut method of excavations.

Geotechnical Parameters. Based on the soil conditions revealed by the borings GB-1 through GB-29, geotechnical parameters were developed for the design of open cut construction for water line, sanitary sewer and sanitary sewer force main installation. The design parameters are provided in Table 1. For design, the groundwater level should be assumed to exist at the ground surface.

Excavation Stability. The open excavation may be shored or laid back to a stable slope or supported by some other equivalent means used to provide safety for workers and adjacent structures, if any. The excavating operations should be in accordance with OSHA Standards, OSHA 2207, Subpart P, latest revision and the City of Houston Standard Specification.

- Excavation Shallower Than 5 Feet - Excavations that are less than 5 feet deep **(critical height)** should be effectively protected when an indication of dangerous ground movement is anticipated.

- Excavations Deeper Than 5 Feet - Excavations that are deeper than 5 feet should be sloped, shored, sheeted, braced or laid back to a stable slope or supported by some other equivalent means or protection such that workers are not exposed to moving ground or cave-ins. The slopes and shoring should be in accordance with the trench safety requirements as per OSHA Standards. The following items provide design criteria for excavation stability.

    (i) OSHA Soil Type. Based on the soil conditions revealed by borings drilled for this study and assumed groundwater level at surface, OSHA soil type "C" should be used for determination of allowable maximum slope and/or the design of shoring along the alignment for full proposed depth of open excavation. For shoring deeper than 20 feet, an engineering evaluation is required.

    (ii) Excavation Support Earth Pressure. Based on the subsurface conditions indicated by our field investigation and laboratory testing results, excavation support earth pressure diagrams are developed and are presented on Figures 1.1 through 1.3. These pressure diagrams can be used for the design of temporary trench bracing. For a trench box, a lateral earth pressure resulting from an equivalent fluid with a unit weight of 96 pcf can be used. The effects of any surcharge loads at the ground surface should be added to the computed lateral earth pressures. A surcharge load, q, will typically result in a lateral load equal to 0.5 q. The above value of equivalent fluid pressure is based on assumption that the groundwater level is near the ground surface, since these conditions may exist after a heavy rain or flooding.

(iii) Bottom Stability. In braced cuts, if tight sheeting is terminated at the base of the cut, the bottom of the excavation can become unstable. The parameters that govern the stability of the excavation base are the soil shear strength and the differential hydrostatic head between the groundwater level within the retained soils and the groundwater level at the interior of the trench excavation. For cut in cohesive soils as predominantly encountered for the proposed excavation depths (6 to 14 feet) in all the borings, the bottom stability can be evaluated as outlined on Figure 2. However, for installation of sanitary sewer line and sanitary sewer force main due to the presence of water bearing silty sand and fine sand with silt at the invert depths and within 3 to 3.5 feet of invert depth, dewatering will be necessary to avoid bottom stability problems.

Groundwater Control. Excavations for the water line, sanitary sewer and sanitary sewer force main may encounter groundwater seepage to varying degrees depending upon the groundwater conditions at the time of construction and the location and depth of the trench. Based on the soil conditions identified in the borings for the proposed water line, sanitary sewer and sanitary sewer force main installation, all the excavations (for excavation depths of 6 to 14 feet) will be in cohesive soils with intermittent cohesionless soils or cohesive over cohesionless soils. In general for cohesive soils as encountered in all the borings for the excavation depths, the groundwater (if encountered) may be managed by collection in excavation bottom sumps for pumped disposal. However, during sanitary sewer line and sanitary sewer force main installation, due to the presence of water bearing silty sand and fine sand with silt at the invert depths and within 3 to 3.5 feet of invert depth, dewatering will be required. Dewatering such as vacuum well points up to 15 feet may be required to lower ground water level at least 5 feet below the bottom of excavation. For open cut excavation near borings GB-4, GB-5, GB-7, GB-

8, GB-19, GB-21, GB-23, GB-24B, GB-25A, GB-27A, GB-28A and GB-29, the excavation will be in cohesive soils or cohesive with the intermittent thin layer of silty sand layer (1 to 2 feet) above the excavation bottom. In these areas the groundwater may be controlled by using eductor well system if can be successfully lowered 5 feet below the excavation bottom or alternatively installing continuous interlock (water tight) sheet piling with trench bottom sumps for pumped disposal. The dewatering system should be pumping well ahead of the time before excavation starts so that a steady state condition (at least 5 feet below the proposed excavation bottom) is achieved. The range of depths where cohesionless soils encountered in borings are presented in the table below.

Location/Street	Boring No.	Range of Depths of Cohesionless Soils Encountered, ft		Soil Type
		From	To	
Wycliffe Drive	GB-4	12	13	Silty Sand
	GB-5	12	14	Fine Sand with silt
	GB-7	12	13	Silty Sand
		16	18	Silty Sand
	GB-8	12	14	Silty Sand
	GB-9	12	20	Silty Sand
	GB-10	0.9	2	Silty Sand
		12	18	Silty Sand
	GB-13	14	16	Fine Sand with Silt
	GB-14	14	16	Silty Sand
	GB-15	11.5	13	Silty Sand
	GB-16	12.5	20	Silty Sand
	GB-17	12	14	Silty Sand
	GB-18	10	18	Silty Sand
Mayfield Road	GB-19	10	16	Silty Sand
	GB-21	10	16	Silty Sand
Ivyridge Road	GB-22	10	16	Fine Sand with silt
Hazelhurst Drive	GB-23	8	14	Clayey Sand and Silty Sand

Location/Street	**Boring No.**	**Range of Depths of Cohesionless Soils Encountered, ft**		**Soil Type**
		From	**To**	
Mayfield Road	GB-24B	10	14	Silty Sand
Ivyridge Road	GB-25A	10	14	Fine Sand with silt
Britt Way Street	GB-27A	12	16	Silty Sand
Shadow Wood Drive	GB-28A	10	14	Silty Sand
	GB-29	12	16	Silty Sand

It is recommended that the actual groundwater conditions should be verified by the contractor at the time of construction and that groundwater control should be performed in general accordance with the City of Houston Standard Specifications, Section 01578.

We appreciate this opportunity to be of service to you. If you have any questions regarding the report, or if we can be of further service to you, please call us.

Sincerely,
GEOTEST ENGINEERING, INC.
TBPE Registration No. F-410

Naresh Kolli, P.E.
Assistant Project Manager

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Copies Submitted: (2)
Enclosures: Trench Support Earth Pressure – Figures 1.1 thru 1.3
Stability of Bottom for Braced Cut – Figure 2
Geotechnical Design Parameter Summary: Open-cut Excavation – Table 1

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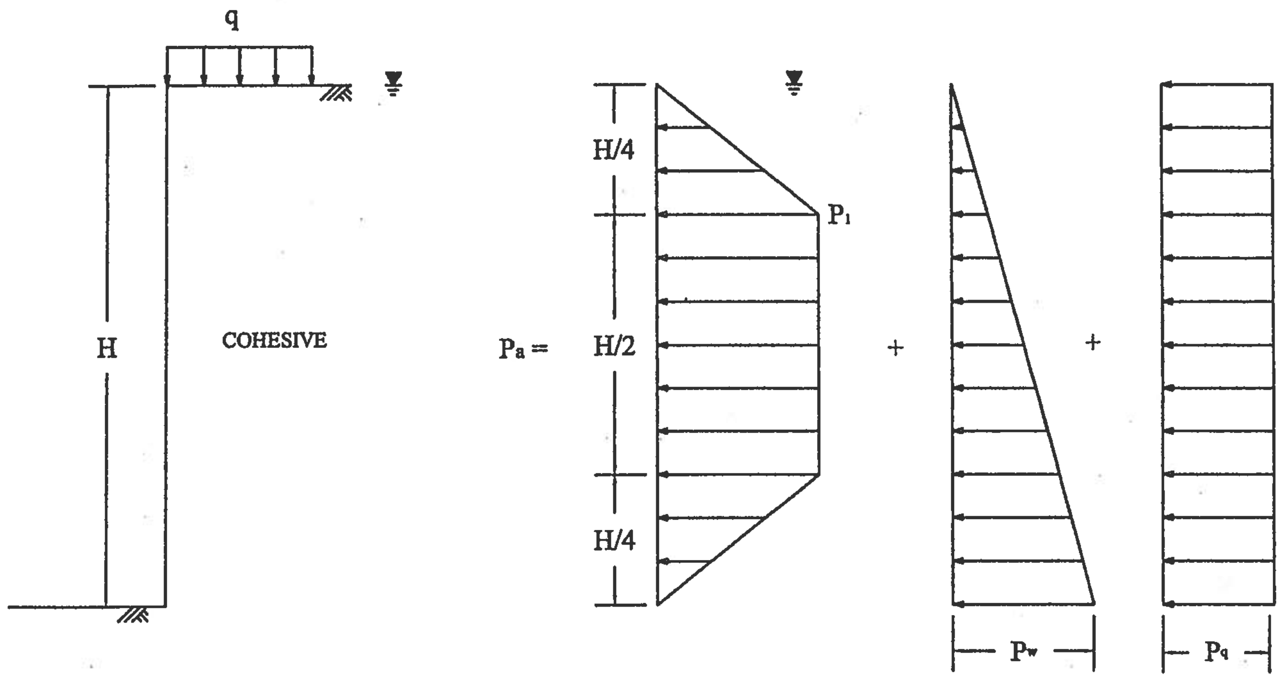

TYPICAL SOIL PARAMETERS

See Table 1 for typical
values of soil parameters

BRACED WALL

For $\gamma H/c \leq 4$

$P_1 = 0.3\ \gamma_c'\ H$
$P_w = \gamma_w\ H = 62.4\ H$
$P_q = 0.5\ q$

Where:

γ_c' = Submerged unit weight of cohesive soil, pcf;
γ_w = Unit weight of water, pcf;
q = Surcharge load at surface, psf;
P_a = Lateral pressure, psf;
P_1 = Active earth pressure, psf;
P_q = Horizontal pressure due to surcharge, psf;
P_w = Hydrostatic pressure due to groundwater, psf;
H = Depth of braced excavation, feet
c = Shear strength of cohesion soil, psf;

TRENCH SUPPORT EARTH PRESSURE

SUBMERGED COHESIVE SOIL

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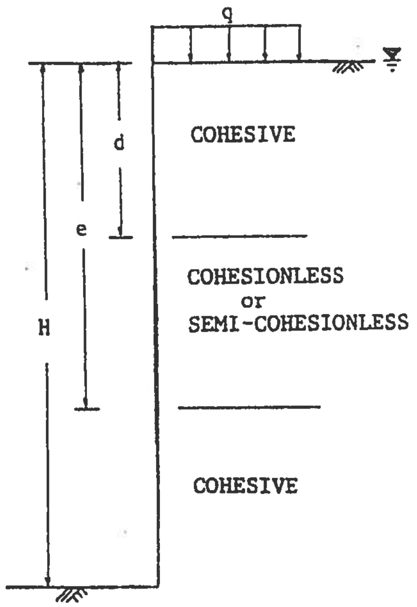
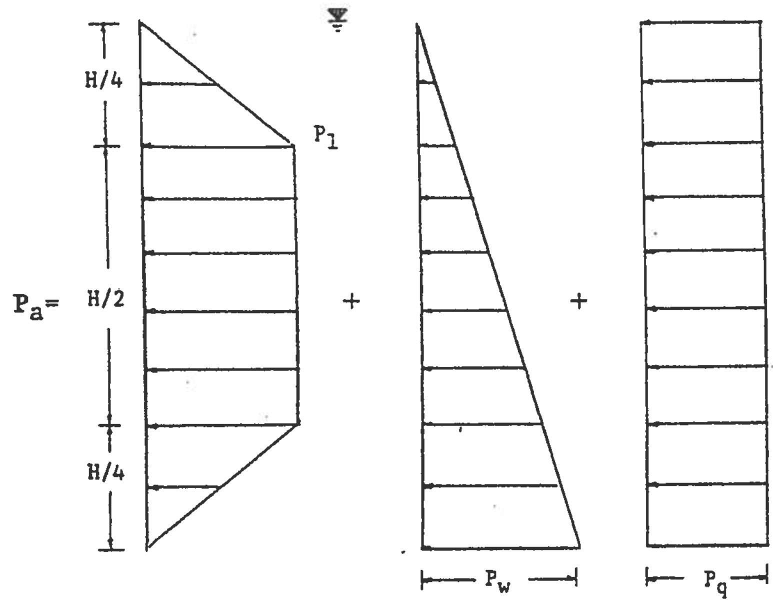


TYPICAL SOIL PARAMETERS



BRACED WALL

See Table 1 for typical values of soil parameters

$$P_1 = 0.3\ \gamma'_{avg}\ H$$

$$P_w = \gamma_w\ H = 62.4\ H$$

$$P_q = 0.5q$$

$$\gamma'_{avg} = \frac{\gamma_c'\ d + \gamma_s'\ (e-d) + \gamma_c'\ (H-e)}{H}$$

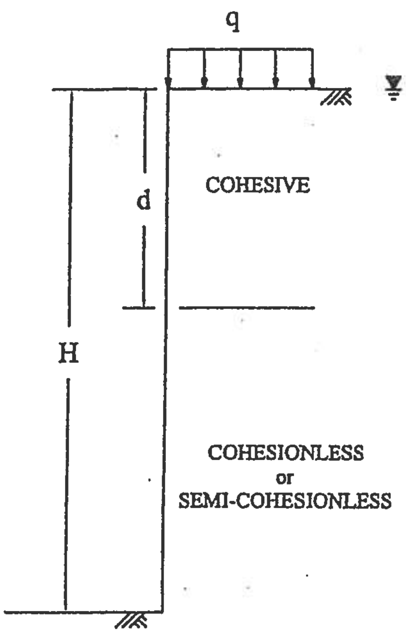
$$\gamma_w = 62.4 \text{ pcf}$$

Where:

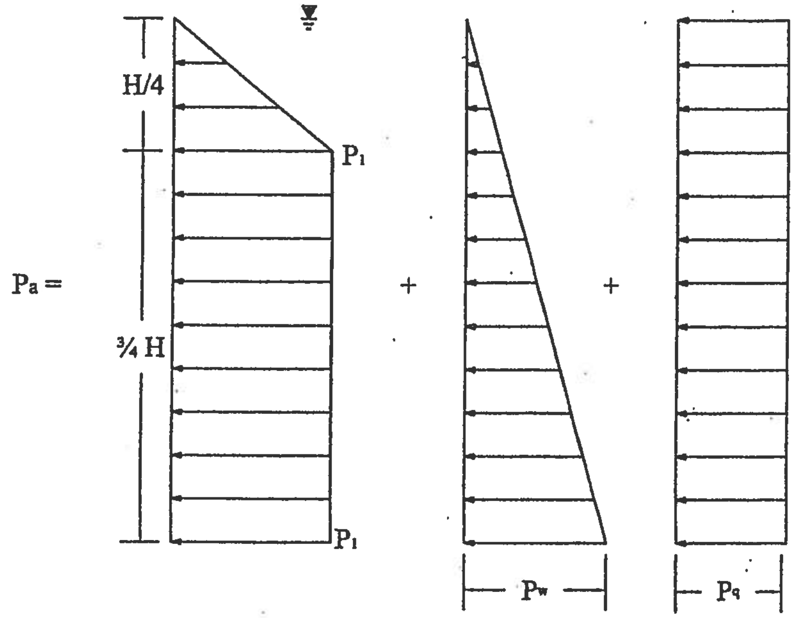
- γ_c' = Submerged unit weight of cohesive soil, pcf ;
- γ_s' = Submerged unit weight of cohesionless or semi-cohesionless soil, pcf ;
- γ_w = Unit weight of water, pcf;
- γ'_{avg} = Average submerged unit weight of soil, pcf ;
- q = Surcharge load at surface, psf;
- P_a = Lateral pressure, psf;
- P_1 = Active earth pressure, psf;
- P_q = Horizontal pressure due to surcharge, psf;
- P_w = Hydrostatic pressure due to groundwater, psf;
- H = Depth of braced excavation, feet

TRENCH SUPPORT EARTH PRESSURE

SUBMERGED COHESIVE SOIL
INTERBEDDED WITH COHESIONLESS OR
SEMI-COHESIONLESS SOIL



TYPICAL SOIL PARAMETERS



BRACED WALL

See Table 1 for typical values of soil parameters

$$\gamma'_{avg} = \frac{\gamma_c' \, d + \gamma_s' \, (H-d)}{H}$$

$P_1 = 0.3\ \gamma'_{avg}\ H$
$P_w = 62.4\ H$
$P_q = 0.5\ q$

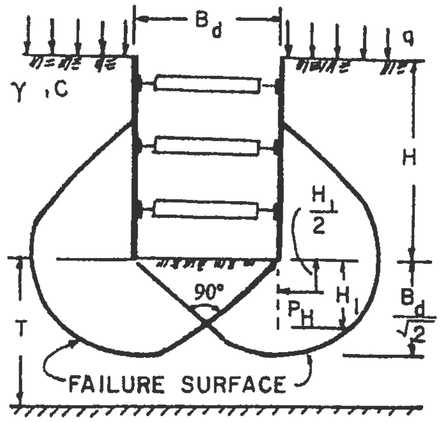
Where:

γ_c' = Submerged unit weight of cohesive soil, pcf;
γ_s' = Submerged unit weight of cohesionless soil, pcf;
γ'_{avg} = Average submerged unit weight of soils, pcf;
q = Surcharge load at surface, psf;
P_a = Lateral pressure, psf;
P_1 = Active earth pressure, psf;
P_q = Horizontal pressure due to surcharge, psf;
P_w = Hydrostatic pressure due to groundwater, psf;
H = Depth of braced excavation, feet

TRENCH SUPPORT EARTH PRESSURE

SUBMERGED COHESIVE SOIL OVER
COHESIONLESS OR SEMI-COHESIONLESS SOIL

CUT IN COHESIVE SOIL,
DEPTH OF COHESIVE SOIL UNLIMITED ($T > 0.7\ B_d$)
L = LENGTH OF CUT



If sheeting terminates at base of cut:

$$\text{Safety factor, } F_S = \frac{N_C C}{\gamma H + q}$$

N_C = Bearing capacity factor, which depends on dimensions of the excavation : B_d, L and H (use N_C from graph below)

C = Undrained shear strength of clay in failure zone beneath and surrounding base of cut

γ = Wet unit weight of soil (see Table 1)

q = Surface surcharge (assumed q = 500 psf)

If safety factor is less than 1.5, sheeting or soldier piles must be carried below the base of cut to insure stability - (see note)

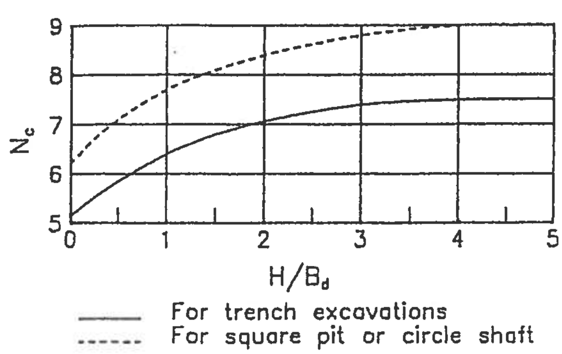
$$H_1 = \text{Buried length} = \frac{B_d}{2} \geq 5 \text{ feet}$$

Note : If soldier piles are used, the center to center spacing should not exceed 3 times the width or diameter of soldier pile .

Force on buried length, P_H:

If $H_1 > \frac{2}{3}\frac{B_d}{\sqrt{2}}$, $P_H = 0.7\,(\gamma H B_d - 1.4CH - \pi C B_d)$ in lbs/ linear foot

If $H_1 < \frac{2}{3}\frac{B_d}{\sqrt{2}}$, $P_H = 1.5H_1\,(\gamma H - \frac{1.4CH}{B_d} - \pi C)$ in lbs/ linear foot



STABILITY OF BOTTOM
FOR
BRACED CUT

TABLE 1

GEOTECHNICAL DESIGN PARAMETER SUMMARY
OPEN-CUT EXCAVATION

Street	Boring Nos.	Stratigraphic Unit	Range of Depths, ft	Wet** Unit Weight, γ, pcf	Submerged Unit Weight, γ', pcf	Undrained Cohesion, psf	Internal Friction Angle, φ, degree
Wycliffe Drive	GB-1 through GB-3	Cohesive	*0-4	127	64	1,000	--
			4-8	125	63	1,500	--
			8-10	129	65	1,200	--
			10-14	125	63	1,500	--
			14-24	128	64	2,000	--
	GB-4 and GB-5	Cohesive	*0-8	126	63	800	--
			8-12	130	65	1,400	--
		Cohesionless	12-14	105	53	--	30
		Cohesive	14-24	130	65	2,000	--
	GB-6A	Cohesive	*0-10	132	66	1,000	--
			10-12	133	67	500	--
			12-16	135	68	1,200	--
			16-22	132	66	2,000	--
	GB-7	Cohesive	*0-8	132	66	1,600	--
			8-12	133	67	500	--
		Cohesionless	12-13	110	55	--	30
		Cohesive	13-16	120	60	1,200	--
		Cohesionless	16-18	115	58	--	30
		Cohesive	18-22	125	63	4,200	--
	GB-8	Cohesive	*0-4	125	63	900	--
			4-12	130	65	1,400	--
		Cohesionless	12-14	110	55	--	30
		Cohesive	14-22	130	65	2,000	--
	GB-9 and GB-10	Cohesive	*0-12	130	65	1,000	--
		Cohesionless	12-20	120	60	--	30
		Cohesive	20-22	125	63	900	--
	GB-11 and GB-12	Cohesive	*0-12	127	64	1,000	--
			12-14	130	65	400	--
			14-21	122	61	1,500	--
	GB-13 and GB-14	Cohesive	*0-4	132	66	1,000	--
		Cohesionless	4-14	125	63	1,400	--
		Cohesive	14-16	106	53	--	30
			16-21	120	60	1,400	--
	GB-15	Cohesive	*0-8	130	65	3,500	--
			8-11.5	125	63	1,000	--
		Cohesionless	11.5-13	110	55	--	30
Sherwood Forest Street	GB-16	Cohesive	*0-8	128	64	2,000	--
			8-12.5	128	64	800	--
		Cohesionless	12.5-20	116	58	--	30
		Cohesive	20-23	125	63	2,000	--
Wycliffe Drive	GB-17	Cohesive	*0-10	132	66	3,000	--
			10-12	132	66	2,000	--
		Cohesionless	12-14	118	59	--	30
		Cohesive	14-20	121	61	800	--
	GB-18	Cohesive	*0-10	125	63	1,200	--
		Cohesionless	10-18	120	60	--	30
		Cohesive	18-20	128	64	1,400	--

TABLE 1 (cont'd)

GEOTECHNICAL DESIGN PARAMETER SUMMARY
OPEN-CUT EXCAVATION

Street	Boring Nos.	Stratigraphic Unit	Range of Depths, ft	Wet** Unit Weight, γ, pcf	Submerged Unit Weight, γ', pcf	Undrained Cohesion, psf	Internal Friction Angle, φ, degree
Mayfield Drive	GB-19	Cohesive	*0-10	134	67	1,000	--
		Cohesionless	10-16	116	58	--	30
		Cohesive	16-20	117	59	1,000	--
Buescher Drive	GB-20	Cohesive	*0-4	132	66	800	--
			4-14	130	65	1,200	--
Mayfield Road and Ivyridge Street	GB-21 and GB-22	Cohesive	*0-10	130	65	1,000	--
		Cohesionless	10-16	115	58	--	30
		Cohesive	16-23	130	65	1,600	--
Hazelhurst Drive	GB-23	Cohesive	*0-8	132	66	1,600	--
		Cohesionless	8-14	125	63	--	30
		Cohesive	14-20	129	64	2,500	--
Mayfield Road and Ivyridge Street	GB-24B and GB-25A	Cohesive	*0-8	130	65	600	--
			8-10	125	63	500	--
		Cohesionless	10-14	116	58	--	30
		Cohesive	14-16	125	63	500	--
			16-23	130	65	1,400	--
Shadow Wood Drive	GB-26	Cohesive	*0-12	128	64	1,000	--
	GB-27 thru GB-29	Cohesive	*0-8	130	65	800	--
			8-12	132	66	1,000	--
		Cohesionless	12-16	116	58	--	30
		Cohesive	16-23	125	63	1,000	--

1. Cohesive soils include Fat Clay, Fat Clay w/sand, Lean Clay w/sand and Sandy Lean Clay.
2. Cohesionless soils include silty sand, fine sand with silt and clayey sand.

* 0 feet – Below the pavement

** The wet unit weight is based on the average value for each layer, where more than one boring is used.